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(54) **POST ION IMPLANT STRIPPER FOR ADVANCED SEMICONDUCTOR APPLICATION**

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C11D 11/00	(2006.01)

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CPC ***H01L 21/31133*** (2013.01); ***G03F 7/425*** (2013.01); *C11D 11/0047* (2013.01)

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CPC ... C11D 11/0047; C11D 7/3218; C11D 3/30; C11D 7/34; G03F 7/425
USPC 510/175, 176; 134/1.3
See application file for complete search history.

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(57) **ABSTRACT**

The present invention relates to a substantially water-free photoresist stripping composition. Particularly, the present invention relates to a substantially water-free photoresist stripping composition useful in removing the photoresist after ion-implant process, comprising: (a) an amine, (b) an organic solvent A, and (c) a co-solvent, wherein the composition is substantially water-free (<3 wt % H_2O). The present invention also provides a process for post-ion implantation stripping by using the composition of the present invention.

22 Claims, 2 Drawing Sheets

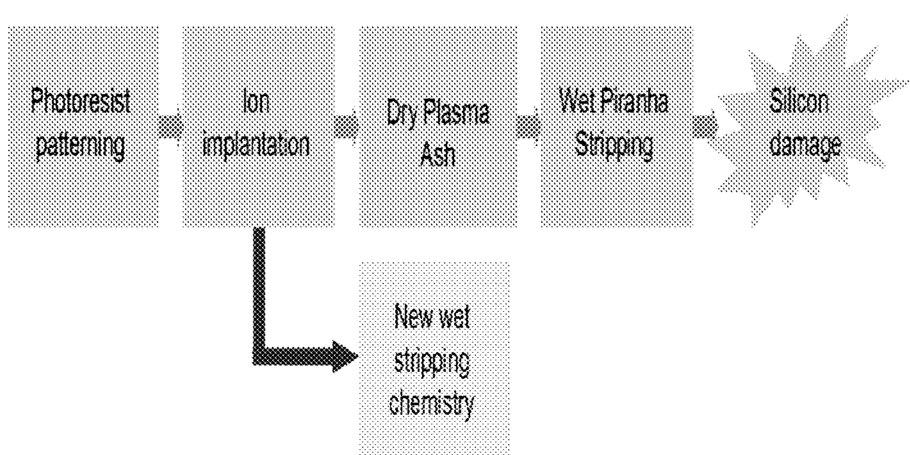

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FIG. 1

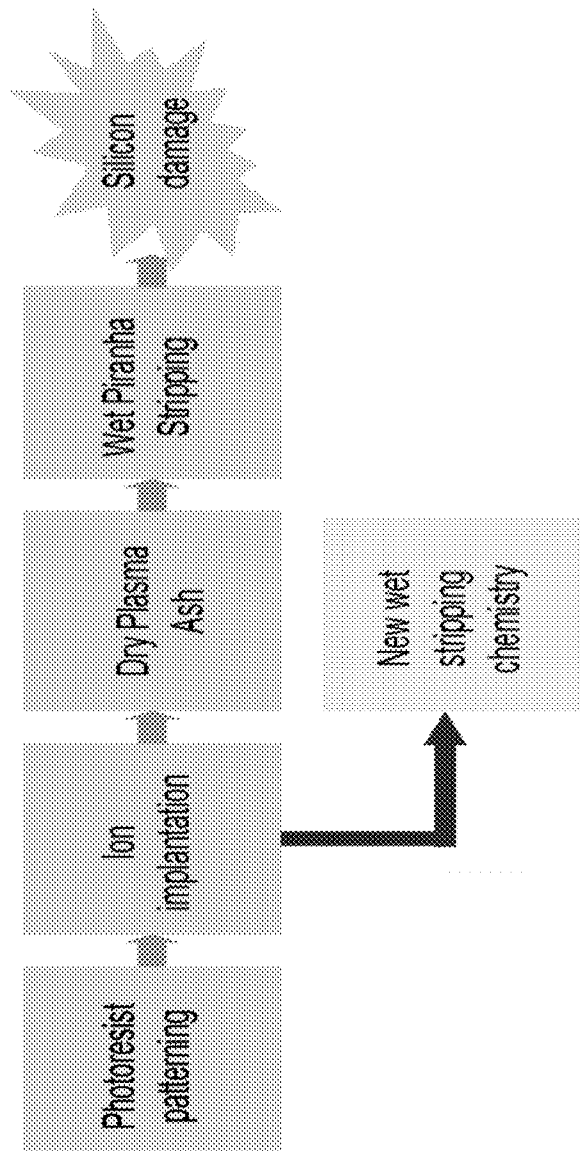
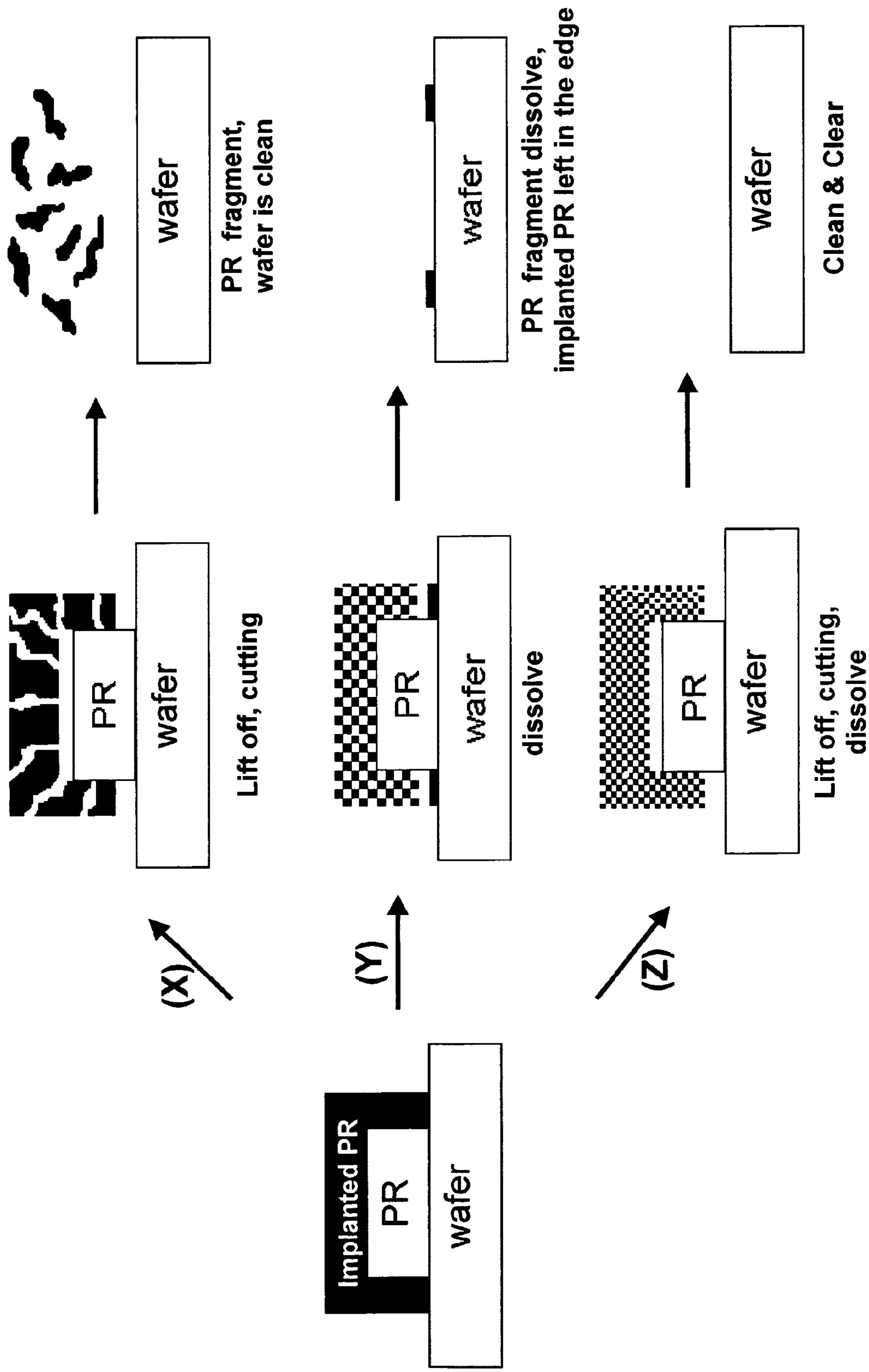

Photoresist patterning
Ion implantation
Dry Plasma Ash
Wet Piranha Stripping
Silicon damage
New wet stripping chemistry

Fig 2


Implanted PR
PR
wafer
(X)
(Y)
(Z)
PR
wafer
Lift off, cutting
PR
wafer
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PR
wafer
Lift off, cutting,
dissolve
wafer
PR fragment,
wafer is clean
wafer
PR fragment dissolve,
implanted PR left in the edge
wafer
Clean & Clear

POST ION IMPLANT STRIPPER FOR ADVANCED SEMICONDUCTOR APPLICATION

FIELD OF THE INVENTION

The present invention relates to a composition for photoresist stripping. Particularly, the present invention relates to a composition for post-ion implantation photoresist stripping.

BACKGROUND OF THE INVENTION

Ion implantation is one of the key processes in the fabrication of semiconductor devices. Dopant ions such as boron, phosphorus or arsenic are created from a high purity gas source and implanted in a semiconductor substrate. Each doped atom creates a charge carrier, either hole or electron and thus modifies the conductivity of the semiconductor device in its vicinity. Ion implantation is commonly applied to the source/drain junction and the channel to achieve desired electrical characteristics of the devices to be produced.

In a typical ion implantation process, a substrate (e.g., silicon wafer) is first subjected to an organic chemical pre-treatment and then a positive-tone photoresist is coated on the substrate. After hot baking, edge bead removal, exposure, development and spin-drying steps, an organic photoresist mask is formed. During ion implantation process, dopants penetrate into the exposed (unmasked) surface of the substrate as well as the photoresist mask. The dopants may react with the photoresist mask to form a relatively nonporous layer, which is commonly known as a "crust." After completion of the ion implantation process, the photoresist mask is then removed by a stripping process. Typical post-ion implantation stripping is done by a dry plasma ashing followed by a wet piranha clean (which uses a mixture of sulfuric acid and hydrogen peroxide as clean agents) and a marangoni dry. Although the above process is widely used in the semiconductor industry, some drawbacks such as long process time and damage to silicon substrates have been noted. Silicon substrate damage such as silicon loss has become a key issue as the critical dimension shrinks to 45 nm and below. Silicon loss of greater than 30 Å may result in undesirable dopant out diffusion and cause device malfunction. For these reasons, the typical process for post-ion implantation stripping process is no longer acceptable and there is need for a new process.

Various methods for removal of the photoresist after ion implantation process are discussed in prior art. For example, U.S. Pat. No. 6,524,936 entitled to Hallock et al. discloses a method which exposes a wafer under UV radiation of 200 nm to 400 nm and at least 100 mJ/cm2 prior to conventional wet or dry stripping processes. In U.S. Pat. No. 5,811,358 entitled to Tseng et al., a three-step procedure is disclosed. The substrate is first stripped with an oxygen and nitrogen/hydrogen plasma at a low temperature (<220° C.) to minimize the photoresist solvent popping problem. Then, a higher temperature (>220° C.) is employed to remove the remaining photoresist. Finally, the substrate is cleaned with ammonium hydroxide and hydrogen peroxide mixtures. Nevertheless, the abovementioned approaches still suffer from unacceptable silicon loss.

Photoresist stripping compositions are disclosed in numerous prior art. For example, U.S. Pat. No. 6,551,973 entitled to Moore discloses a stripping composition comprising benzyl-trimethylammonium hydroxide (BTMAH) and a solvent system comprising alkylsulfoxide and optionally a glycol co-solvent, corrosion inhibitor and non-ionic surfactant for removing polymeric organic substances from metalized inorganic substrates. In U.S. Publication No. 2007/0099805 to Phenis et al., a stripper solution comprising dimethyl sulfoxide and a quaternary ammonium hydroxide and an alkanolamine is disclosed. However, attempts to employ conventional stripping compositions to remove a photoresist after ion implantation, especially heavy dose ion implantation, have always failed because the photoresist becomes nonporous and forms a crust after ion implantation. The nonporous crust prevents the penetration of the wet chemicals into the inner portion of the photoresist and thus significantly reduces the contact area between the wet chemicals and photoresist. In addition, the crust portion is highly non-uniform and thus the process difficulty of a wet clean is increased. Accordingly, post-ion implantation stripping by conventional wet chemicals is impractical.

SUMMARY OF THE INVENTION

One of the objects of the invention is to provide a substantially water-free photoresist stripping composition which is useful in removing the photoresist after ion implantation process. The composition of the present invention comprises:

(a) an amine,

(b) an organic solvent A, and

(c) a co-solvent,

wherein the composition is substantially water-free.

In a preferred embodiment of the present invention, the amine is a quaternary ammonium hydroxide.

In a more preferred embodiment of the present invention, the amine is benzyl-trimethylammonium hydroxide (BTMAH).

In another more preferred embodiment of the present invention, the amine is a tetramethylammonium hydroxide (TMAH).

Another object of the present invention is to provide a method for post-ion implantation stripping. The method comprises the steps of:

(a) providing a substrate having implanted photoresists thereon, and

(b) contacting the substrate with the composition of the present invention for a period of time sufficient to remove the photoresist from the substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic flow chart comparing typical post-ion implantation stripping with the process of the present invention.

FIG. **2** is a schematic diagram of possible mechanisms in a stripping process.

DETAILED DESCRIPTION OF THE INVENTION

The first object of the present invention is to provide a photoresist stripping composition capable of removing photoresist from a substrate after ion implantation. The stripping composition of the present invention comprises:

(a) an amine,

(b) an organic solvent A, and

(c) a co-solvent,

wherein the composition is substantially water-free.

The amine in the composition of the present invention can break down the polymeric frameworks of the cured photoresist and lift off fragments of the cured photoresist.

Any suitable primary, secondary, tertiary or quaternary amines can be used in the composition of the present invention. Suitable primary amines include, but are not limited to, ethanolamine (MEA), N-methylethanolamine (NMEA), cyclohexylamine and hydroxylamine (HA). Suitable secondary amines include, but are not limited to, diethylhydroxyliamine, diethylamine and quinoline. Suitable tertiary amines include, but are not limited to, dimethylethanolamine and trimethylamine. Suitable quaternary amines include, but are not limited to, tetramethylammonium hydroxide (TMAH), benzyl-trimethylammonium hydroxide (BTMAH), tetraethylammonium hydroxide (TEAH) and tetrabutylammonium hydroxide (TBAH).

Preferred amines are quaternary ammonium hydroxides. Among the quaternary ammonium hydroxides, BTMAH and TMAH are surprisingly effective and thus are most preferred.

The amount of amine in the composition of the present invention can vary from 1 to 10 wt %, preferably 1 to 4 wt %.

The organic solvent A and co-solvent of the present invention function differently. The organic solvent A of the present invention is capable of removing photoresists from the substrate by lift-off and cutting mechanisms, which are shown as (X) in FIG. **2**. Using solvent A alone without a co-solvent can lift off photoresists from the substrate, but the stripper solution then becomes turbid due to the suspended photoresist fragments in the solution. The photoresist fragments will decrease the load capacity of the stripping composition and contaminate the substrate as well as the equipment.

On the other hand, the co-solvent of the present invention is less effective in lifting photoresists from a substrate, but can dissolve photoresist fragments so as to increases the load capacity of the stripping composition. The co-solvent alone cannot completely remove the photoresist from a substrate and some photoresist residues, especially the "crust," will remain on the substrate. The mechanism of the co-solvent is shown as (Y) in FIG. **2**.

Accordingly, the composition of the present invention properly combines a solvent A and a co-solvent to achieve excellent stripping performance. The mechanism is schematically shown as (Z) in FIG. **2**.

Solvent A and the co-solvent must be carefully selected. For safety, a suitable solvent A and the co-solvent should have a flash point higher by at least 10° C., preferably 30° C., than the process temperature and a boiling point at least 40° C. higher than the process temperature. The melting point should be lower than room temperature and preferably lower than 0° C. to avoid crystallization during storage or shipping. Nevertheless, if a single solvent does not have all of the above physical properties, for example DMSO has a melting point of 18.5° C. but is particularly effective at lifting off or dissolving implanted photoresists, it can be mixed with other suitable solvent(s) to meet the requirements.

A suitable organic solvent A is selected from alkysulfoxides, such as dimethyl sulfoxide (DMSO), dimethyl sulfone ($DMSO_2$) and sulfolane; ketones, such as 1-methyl-2-pyrrolidinone (NMP), γ-butyrolactone (BLO)(GBL), ethyl methyl ketone, 2-pentanone, 3-pentanone, 2-exanone and isobutyl methyl ketone; alcohols, such as $C_nH_{2n+1}OH$ wherein n=3 to 10, for example, 1-propanol, 2-propanol, butyl alcohol, pentanol, 1-hexanol, 1-heptanol, and 1-octanol, ethyldiglycol (EDG), butyldiglycol (BDG) and benzyl alcohol; aldehydes, such as benzaldehyde; alkanes, such as tridecane, dodecance, undecance and decance; amines, such as N,N-Dimethylethanolamine, di-n-propylamine, tri-n-propylamine, isobutylamine, sec-butylamine, cyclohexylamine, methylamiline, o-toluidine, m-toluidine, o-chloroaniline, m-chloroaniline, octylamine, N,N-diethylhydroxylamine, quinoline, N,N-dimethylethanolamine or N,N-dimethylformamide; or a combination thereof.

A suitable co-solvent is selected from alcohols, including primary, secondary and tertiary alcohols, such as isopropyl alcohols, isobutyl alcohols, sec-butyl alcohols, isopentyl alcohols, tert-pentyl alcohols, ethylene glycol (EG), propylene glycol, 1,2-propanediol, 1,3-propanediol, 1,2,3-propanetriol and 1-amino-2-propanol; esters, such as isopropyl acetate and ethyl acetoacetate; amines containing a hydroxy group, such as triethanol amine, ethanolamine (MEA), formamide, dimethylacetamide (DMAC), 2-(methylamino_ethanol (NMEA), and N-ethyldiisopropylamine; or a combination thereof.

Among the above organic solvents, DMSO, NMP, benzyl alcohol, propanol, butyldiglycol, pentanol, N,N-dimethylethanol amine, benzaldehyde or a mixture thereof is preferred for use in the present invention as solvent A. DMSO, NMP, benzyl alcohol, butyldiglycol and a mixture thereof are more preferred.

Ethylene glycol, 1,2-propanediol, 1-amino-2-propanol, triethanol amine, MEA, isopropyl acetate or a mixture thereof is preferred for use in the present invention as a co-solvent and ethylene glycol, triethanol amine, MEA or a mixture thereof is more preferred.

The amount of the solvent A and co-solvent basically ranges from 90 to 99 wt % of the composition, if no other additives are added. The ratio of the solvent A to co-solvent is not critical.

The stripping composition of the present invention can optionally contain additives such as chelating agents and surfactants. Suitable chelating agents include, but are not limited to, ethylenediaminetetraacetic acid (EDTA), diethylenetriaminepentaacetic acid (DTPA) and 2,4-pentanedione. Suitable surfactants include, but are not limited to, non-ionic alkoxylated alcohols, nonyl-phenols and nonyl-ethoxylates. The amount of each additive can vary depending on needs and can be decided by a skilled person in view of prior art. Preferably, the total amount of additives is less than about 1 wt % of the composition.

Unlike most conventional stripping compositions, the stripping composition of the present invention is substantially water-free, that is, the water content must be less than 3 wt %, preferably less than 1 wt %, and more preferably less than 0.5 wt % so as to prevent damage to a silicon substrate. Silicon loss is highly correlated with the water content of the composition.

Another object of the present invention is to provide a wet process for post-ion implantation. The method comprises the steps of:

(a) providing a substrate having implanted photoresists thereon, and

(b) contacting the substrate with the composition of the present invention for a period of time sufficient to remove the photoresist from the substrate.

It should be noted that the stripping process of the present invention does not require dry plasma ashing, so it is advantageous in reduction of cycle time and energy consumed.

The method of the present invention can be performed in any suitable equipment such as conventional wet bench or cleansers. The contact of the substrate with the composition can be done by any suitable conventional means such as immersion, rinsing, spraying and jetting.

In a preferred embodiment of the present invention, the method is performed in a wet bench. The process can be conducted at a temperature of 25° C. to 90° C., preferably 40° C. to 80° C., and more preferably 60° C. to 80° C. The temperature is much lower than the process temperature of piranha clean, which is normally 120° C. to 140° C. It is believed that elevated temperature increases silicon loss of a substrate, so a lower temperature is beneficial.

Generally, implanted photoresists can be completely removed from a substrate in 20 min to 2 hr. Actual time depends on the types of photoresists, equipment used and process conditions.

EXAMPLES

The present invention is illustrated below in detail by the examples, which are not intended to limit the scope of the present invention. It will be apparent that any modifications or alterations that are obvious for persons skilled in the art fall within the scope of the disclosure of the specification.

Experiment 1 H_2O vs. Polysilicon Etching Rate

The following experiments were performed to evaluate the influence of the water content on the polysilicon etching rate. Different amounts of TMAH or its methanol solution (Exp. 1 to 6) and methanol solutions of BTMAH (Exp. 7 to 9) were added into DMSO. Different amounts of water were added to some solutions (Exp. 1 to 5, 8 and 9). Polysilicon wafers were immersed in the solutions under various process conditions and the thickness difference of each wafer was measured. The results are shown in Table 1.

TABLE 1

Poly-silicon Wafer	Formulation (wt. %)	Process Condition	Poly Si Etch Rate (Å/min)
Exp. 1	92%DMSO + 2% TMAH + 6%H_2O	40° C., 6 hr	>4
Exp. 2	92%DMSO + 2% TMAH + 6%H_2O	60° C., 6 hr	>7
Exp. 3	92%DMSO + 2% TMAH + 6%H_2O	80° C., 6 hr	>20
Exp. 4	80%DMSO + 2% TMAH + 18%H_2O	80° C., 6 hr	>350
Exp. 5	2% TMAH + 98%H_2O	80° C., 6 hr	>570

TABLE 1-continued

Poly-silicon Wafer	Formulation (wt. %)	Process Condition	Poly Si Etch Rate (Å/min)
Exp. 6	84%DMSO + 4%TMAH + 12%MeOH	80° C., 60 min	not detectable
Exp. 7	90%DMSO + 4% BTMAH + 6%MeOH	80° C., 60 min	not detectable
Exp. 8	addition of 1% H_2O to exp. 7	80° C., 60 min	not detectable
Exp. 9	addition of 3% H_2O to exp. 7	80° C., 60 min	>0.5

The results show that the increase of H_2O significantly increases the polysilicon etch rate. In addition, Exp.1 to 3 show that higher temperature results in higher polysilicon etch rate.

Experiments 2 to 5

The stripping ability of different compositions under various conditions was tested, and the results are shown in the following Tables 2 to 5.

TABLE 2

Exp.		amine (wt. %)		solvent (wt. %)		temp. (° C.)	time (min)	PR removal ability	appearance of solution: before stripping	appearance of solution: after stripping
S-001	amine	MEA	4	DMSO	96	60	60	Ok	clear	turbid
S-002		Cyclohexyl-amine	4			60	60	Ok	clear	turbid
S-003		Diethylhydroxyl-amine	4			60	60	Ok	clear	turbid
S-004		Diethylamine	4			60	60	Ok	clear	turbid
S-005		Quinoline	4			60	60	Ok	clear	turbid
S-006		Dimethylethanol-amine	4			60	60	Ok	clear	turbid
S-007		Trimethylamine	4			60	60	Ok	clear	turbid
S-008		TBAH	4			60	60	Ok	clear	turbid
S-009		TMAH + MeoH	4 + 12		84	60	60	Ok	clear	turbid
S-010		BTMAH + MeOH	4 + 6		90	60	60	Ok	clear	turbid

Table 2 shows that among the used amines, TMAH shows surprisingly effective photoresist stripping performance at the given process conditions. It should be noted that other amines are also capable of removing photoresists, although their performance is not as good as TMAH and BTMAH.

TABLE 3

Exp.	amine (MeOH) (wt. %)		solvent (wt. %)		temp. (° C.)	time (min)	performance
S-011	TMAH	4(12)	DMSO	84	80	60	A
S-009	TMAH	4(12)	DMSO	84	60	60	A
S-012	TMAH	4(12)	DMSO	84	55	60	B
S-013	TMAH	4(12)	DMSO	84	50	60	B
S-014	TMAH	4(12)	DMSO	84	45	60	B
S-015	TMAH	4(12)	DMSO	84	60	45	B
S-016	TMAH	4(12)	DMSO	84	60	30	B
S-017	TMAH	4(12)	DMSO	84	60	15	B
S-018	TMAH	3(9)	DMSO	88	60	60	A
S-019	TMAH	2(6)	DMSO	92	60	60	A
S-020	TMAH	1(3)	DMSO	96	60	60	A
S-021	BTMAH	4(6)	DMSO	90	80	60	A

TABLE 3-continued

Exp.		amine (MeOH) (wt. %)	solvent (wt. %)		temp. (° C.)	time (min)	performance
S-022	BTMAH	4(6)	DMSO	90	75	60	A
S-023	BTMAH	4(6)	DMSO	90	70	60	A
S-024	BTMAH	4(6)	DMSO	90	65	60	B
S-025	BTMAH	4(6)	DMSO	90	60	60	C
S-026	BTMAH	4(6)	DMSO	90	80	45	A
S-027	BTMAH	4(6)	DMSO	90	80	30	B
S-028	BTMAH	4(6)	DMSO	90	80	15	B
S-029	BTMAH	3(4.5)	DMSO	92.5	80	60	A
S-030	BTMAH	2(3)	DMSO	95	80	60	A
S-010	BTMAH	1(1.5)	DMSO	97.5	80	60	A

A: clean;
B: little PR residue on the wafer;
C: some PR residue on the wafer

Table 3 shows that the process window for TMAH is broader than BTMAH. For BTMAH, 60 min at 70° C. is required to complete the stripping. For TMAH, 60 min at 60° C. is required. As mentioned above, elevated temperature is disadvantageous because it increases the damage to silicon substrate.

TABLE 4

									appearance of solution	
Exp.	Amine	(MeOH) (%)	type	solvent A	(%)	temp. (° C.)	time (min)	Performance	before stripping	after stripping
S-031	TMAH	4(12)	alkysulfoxide	DMSO	84	60	60	A	clear	turbid
S-032	TMAH	4(12)	ketone	NMP	84	60	60	A	clear	turbid
S-033	TMAH	4(12)	amine	Triethanol amine	84	60	60	C	clear	clear
S-034	TMAH	4(12)		N,N-Dimethyl-ethanolamine	84	60	60	A	clear	turbid
S-035	TMAH	4(12)		MEA	84	60	60	C	clear	clear
S-036	TMAH	4(12)	Alcohol	Propanol	84	60	60	A	clear	turbid
S-037	TMAH	4(12)		Pentanol	84	60	60	A	clear	turbid
S-038	TMAH	4(12)		Butyldiglycol (BDG)	84	60	60	A	clear	turbid
S-039	TMAH	4(12)		Benzl alcohol	84	60	60	A	clear	turbid
S-040	TMAH	4(12)		Ethyl glycol	84	60	60	C	clear	clear
S-041	TMAH	4(12)		1,2-propanediol	84	60	60	C	clear	clear
S-042	TMAH	4(12)		1-amino-2-propanol	84	60	60	C	clear	clear
S-043	TMAH	4(12)	aldehyde	Benzaldehyde	84	60	60	A	clear	turbid
S-044	TMAH	4(12)	ester	Isopropyl acetate	84	60	60	C	clear	clear

A: clean;
C: some PR residue on the wafer

Various solvents have been tested. Table 4 shows that the tested solutions either have acceptable photoresist removal ability but cause the solution to become turbid after stripping (which is classified as solvent A), or have poor photoresist removal ability but can dissolve photoresists (which is classified as a co-solvent). A solvent effective at both photoresist removal and dissolving is not found.

TABLE 5

										appearance of solution	
Exp.	Amine	(MeOH) (%)	solvent A	(%)	co-solvent	(%)	temp. (° C.)	time (min)	Performance	before stripping	after stripping
S-045	TMAH	4(12)	DMSO	42	Ethylene glycol	42	60	60	Ok	clear	clear
S-046	TMAH	4(12)		42	1,2-propanediol	42	60	60	Ok	clear	clear
S-047	TMAH	4(12)		12	Triethanol	72	60	60	Ok	clear	clear
S-048	TMAH	4(12)		42	amine	42	60	60	Ok	clear	clear
S-049	TMAH	4(12)		12	MEA	72	60	60	Ok	clear	clear
S-050	TMAH	4(12)		42		42	60	60	Ok	clear	clear
S-051	TMAH	1(3)		10		86	60	60	Ok	clear	clear
S-052	TMAH	4(12)	NMP	42	Ethylene glycol	42	60	60	Ok	clear	clear
S-053	TMAH	4(12)		42	1,2-propanediol	42	60	60	Ok	clear	clear

TABLE 5-continued

Exp.	Amine (MeOH) (%)		solvent A (%)		co-solvent (%)		temp. (° C.)	time (min)	Performance	appearance of solution before stripping	appearance of solution after stripping
S-054	TMAH	4(12)		42	Triethanol amine	42	60	60	Ok	clear	clear
S-055	TMAH	4(12)		42	MEA	42	60	60	Ok	clear	clear
S-056	TMAH	4(12)	Benzyl	72	Ethylene	12	60	60	Ok	clear	clear
S-057	TMAH	4(12)	alcohol	42	glycol	42	60	60	Ok	clear	clear
S-058	TMAH	4(12)		42	1,2-	42	60	60	Ok	clear	clear
S-059	TMAH	1(3)		10	propanediol	86	60	60	Ok	clear	clear
S-060	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-061	TMAH	4(12)		42	1-amino-2-	42	60	60	Ok	clear	clear
S-062	TMAH	1(3)		10	propanol	86	60	60	Ok	clear	clear
S-063	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-064	TMAH	4(12)		42	Triethanol	42	60	60	Ok	clear	clear
S-065	TMAH	1(3)		10	amine	86	60	60	Ok	clear	clear
S-066	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-067	TMAH	4(12)		42	MEA	42	60	60	Ok	clear	clear
S-068	TMAH	1(3)		10		86	60	60	Ok	clear	clear
S-069	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-070	TMAH	4(12)	Pentanol	42	Ethylene glycol	42	60	60	Ok	clear	clear
S-071	TMAH	1(3)		10		86	60	60	Ok	clear	clear
S-072	TMAH	4(12)		42	1,2-	42	60	60	Ok	clear	clear
S-073	TMAH	1(3)		10	propanediol	86	60	60	Ok	clear	clear
S-074	TMAH	4(12)		42	Triethanol	42	60	60	Ok	clear	clear
S-075	TMAH	1(3)		10	amine	86	60	60	Ok	clear	clear
S-076	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-077	TMAH	4(12)		42	MEA	42	60	60	Ok	clear	clear
S-078	TMAH	1(3)		10		86	60	60	Ok	clear	clear
S-079	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-080	TMAH	4(12)	Propanol	42	Ethylene glycol	42	60	60	Ok	clear	clear
S-081	TMAH	4(12)		42	1,2-propanediol	42	60	60	Ok	clear	clear
S-082	TMAH	4(12)		42	1-amino-2-	42	60	60	Ok	clear	clear
S-083	TMAH	1(3)		10	propanol	86	60	60	Ok	clear	clear
S-084	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-085	TMAH	4(12)		42	Triethanol amine	42	60	60	Ok	clear	clear
S-086	TMAH	4(12)		42	MEA	42	60	60	Ok	clear	clear
S-087	TMAH	1(3)		10		86	60	60	Ok	clear	clear
S-088	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-089	TMAH	4(12)	Butyl-	42	Ethylene glycol	42	60	60	Ok	clear	clear
S-090	TMAH	1(3)	diglycol	10		86	60	60	Ok	clear	clear
S-091	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-092	TMAH	4(12)		42	1,2-	42	60	60	Ok	clear	clear
S-093	TMAH	1(3)		10	propanediol	86	60	60	Ok	clear	clear
S-094	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-095	TMAH	4(12)		42	1-amino-2-	42	60	60	Ok	clear	clear
S-096	TMAH	1(3)		10	propanol	86	60	60	Ok	clear	clear
S-097	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-098	TMAH	4(12)		42	Triethanol amine	42	60	60	Ok	clear	clear
S-099	TMAH	4(12)		42	MEA	42	60	60	Ok	clear	clear
S-100	TMAH	1(3)		10		86	60	60	Ok	clear	clear
S-101	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-102	TMAH	4(12)	Di-	42	Ethylene glycol	42	60	60	Ok	clear	clear
S-103	TMAH	1(3)	methyl	10		86	60	60	Ok	clear	clear
S-104	TMAH	1(3)	ethanol-	86		10	60	60	Ok	clear	clear
S-105	TMAH	4(12)	amine	42	1,2-propanediol	42	60	60	Ok	clear	clear
S-106	TMAH	4(12)		42	1-amino-2-	42	60	60	Ok	clear	clear
S-107	TMAH	1(3)		10	propanol	86	60	60	Ok	clear	clear
S-108	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-109	TMAH	4(12)		42	Triethanol amine	42	60	60	Ok	clear	clear
S-110	TMAH	4(12)		42	MEA	42	60	60	Ok	clear	clear
S-111	TMAH	1(3)		10		86	60	60	Ok	clear	clear
S-112	TMAH	1(3)		86		10	60	60	Ok	clear	clear
S-113	TMAH	4(12)	Benzyaldehyde	42	Ethylene glycol	42	60	60	Ok	clear	clear
S-114	TMAH	4(12)		42	1,2-propanediol	42	60	60	Ok	clear	clear
S-115	TMAH	4(12)		42	Triethanol amine	42	60	60	Ok	clear	clear

Table 5 shows the performance of the embodiments of the present invention. It should be noted that the ratio of solvent A to co-solvent is not critical.

What is claimed is:

1. A composition consisting of:

(a) an amine selected from the group consisting of tetramethylammonium hydroxide, benzyl-trimethylammonium hydroxide, tetraethylammonium hydroxide and tetrabutylammonium hydroxide, and a combination thereof;

(b) an organic solvent A selected from the group consisting of dimethyl sulfoxide (DMSO), dimethyl sulfone ($DMSO_2$), γ-butyrolactone (BLO)(GBL), ethyl methyl ketone, 2-pentanone, 3-pentanone, 2-hexanone, isobutyl methyl ketone, 1-propanol, 2-propanol, butyl alcohol, pentanol, 1-hexanol, 1-heptanol, 1-octanol, ethyldiglycol (EDG), butyldiglycol (BDG), benzyl alcohol, benzaldehyde, tridecane, dodecane, undecane, decane, N,N-Dimethylethanolamine, di-n-propylamine, tri-n-propylamine, isobutylamine, sec-butylamine, cyclohexylamine, methylamiline, o-toluidine, m-toluidine, o-chloroaniline, m-chloroaniline, octylamine, N,N-diethylhydroxylamine, quinoline, N,N-dimethylethanolamine, and N,N-dimethylformamide, and a combination thereof;

(c) a co-solvent selected from the group consisting of an isopropyl alcohol, an isobutyl alcohol, a sec-butyl alcohol, an isopentyl alcohol, a tort-pentyl alcohol, ethylene glycol (EG), propylene glycol, 1,2-propanediol, 1,3-propanediol, 1,2,3-propanetriol, 1-amino-2-propanol, isopropyl acetate, ethyl acetoacetate, triethanol amine, ethanolamine (MEA), formamide, dimethylacetamide (DMAC), 2-(methylamino_ethanol (NMEA), and N-ethyldiisopropylamine, and a combination thereof; and

(d) less than 1 wt % water; and

(e) optional additives.

2. The composition of claim **1**, wherein said amine is present in an amount of 1 to 10 wt %.

3. The composition of claim **1**, wherein said amine is present in an amount of 1 to 4 wt %.

4. The composition of claim **1**, wherein the organic solvent A is selected from the group consisting of dimethyl sulfoxide (DMSO), benzyl alcohol, 1-propanol, 2-propanol, butyldiglycol, pentanol, N,N-dimethylethanol amine, and Benzaldehyde and a combination thereof.

5. The composition of claim **1**, wherein the organic solvent A is selected from the group consisting of dimethyl sulfoxide (DMSO), benzyl alcohol, and butyldiglycol and a combination thereof.

6. The composition of claim **1**, wherein the co-solvent is selected from the group consisting of ethylene glycol, 1,2-propanediol, 1-amino-2-propanol, triethanol amine, ethanolamine (MEA), and isopropyl acetate and a combination thereof.

7. The composition of claim **1**, wherein the co-solvent is selected from the group consisting of ethylene glycol, triethanol amine, and ethanolamine (MEA) and a combination thereof.

8. The composition of claim **1**, wherein water is present in an amount of less than 0.5 wt %.

9. A method for post-ion implantation stripping, comprising

contacting a substrate having an implanted photoresist thereon with the composition of claim **1** under a process temperature for a period of time sufficient to remove the photoresist from the substrate.

10. The method of claim **9**, wherein the process temperature is 25° C. to 90° C.

11. The method of claim **9**, wherein the process temperature is 40° C. to 80° C.

12. The method of claim **9**, wherein the process temperature is 60° C. to 80° C.

13. The method of claim **9**, wherein the period of time is 20 min to 1 hr.

14. The composition of claim **1**, wherein the amine is tetramethylammonium hydroxide (TMAH).

15. The composition of claim **14**, wherein said amine is tetramethylammonium hydroxide (TMAH) which is present in an amount of 1 to 4 wt. %.

16. The composition of claim **15**, wherein water is present in an amount of less than 0.5 wt %.

17. The composition of claim **1**, wherein:

the amine is tetramethylammonium hydroxide (TMAH);

the organic solvent A is at least one selected from the group consisting of dimethyl sulfoxide (DMSO), benzyl alcohol, and butyldiglycol; and

the co-solvent is at least one selected from the group consisting of ethylene glycol, triethanol amine, and ethanolamine (MEA).

18. The composition of claim **17**, wherein water is present in an amount of less than 0.5 wt %.

19. A composition consisting of:

(a) an amine selected from the group consisting of tetramethylammonium hydroxide, benzyl-trimethylammonium hydroxide, tetraethylammonium hydroxide and tetrabutylammonium hydroxide, and a combination thereof;

(b) an organic solvent A selected from the group consisting of dimethyl sulfoxide (DMSO), dimethyl sulfone ($DMSO_2$), γ-butyrolactone (BLO)(GBL), ethyl methyl ketone, 2-pentanone, 3-pentanone, 2-hexanone, isobutyl methyl ketone, 1-propanol, 2-propanol, butyl alcohol, pentanol, 1-hexanol, 1-heptanol, 1-octanol, ethyldiglycol (EDG), butyldiglycol (BDG), benzyl alcohol, benzaldehyde, tridecane, dodecane, undecane, decane, N,N-Dimethylethanolamine, di-n-propylamine, tri-n-propylamine, isobutylamine, sec-butylamine, cyclohexylamine, methylamiline, o-toluidine, m-toluidine, o-chloroaniline, m-chloroaniline, octylamine, N,N-diethylhydroxylamine, quinoline, N,N-dimethylethanolamine, and N,N-dimethylformamide, and a combination thereof;

(c) a co-solvent selected from the group consisting of an isopropyl alcohol, an isobutyl alcohol, a sec-butyl alcohol, an isopentyl alcohol, a tert-pentyl alcohol, ethylene glycol (EG), propylene glycol, 1,2-propanediol, 1,3-propanediol, 1,2,3-propanetriol, 1-amino-2-propanol, isopropyl acetate, ethyl acetoacetate, triethanol amine, ethanolamine (MEA), formamide, dimethylacetamide (DMAC), 2-(methylamino_ethanol (NMEA), and N-ethyldiisopropylamine, and a combination thereof; and

(d) less than 1 wt % water.

20. The composition of claim **1**, wherein said optional additives are present and are selected from the group consisting of a chelating agent, a surfactant and a mixture thereof.

21. The composition of claim **20**, wherein said additive is a chelating agent selected from the group consisting of ethylenediaminetetraacetic acid, diethylenetriaminepentaacetic acid, 2,4-pentanedione and a mixture thereof.

22. The composition of claim **20**, wherein said additive is a surfactant selected from the group consisting of a non-ionic alkoxylated alcohol, a nonyl-phenol, a nonyl-ethoxylate and a mixture thereof.

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